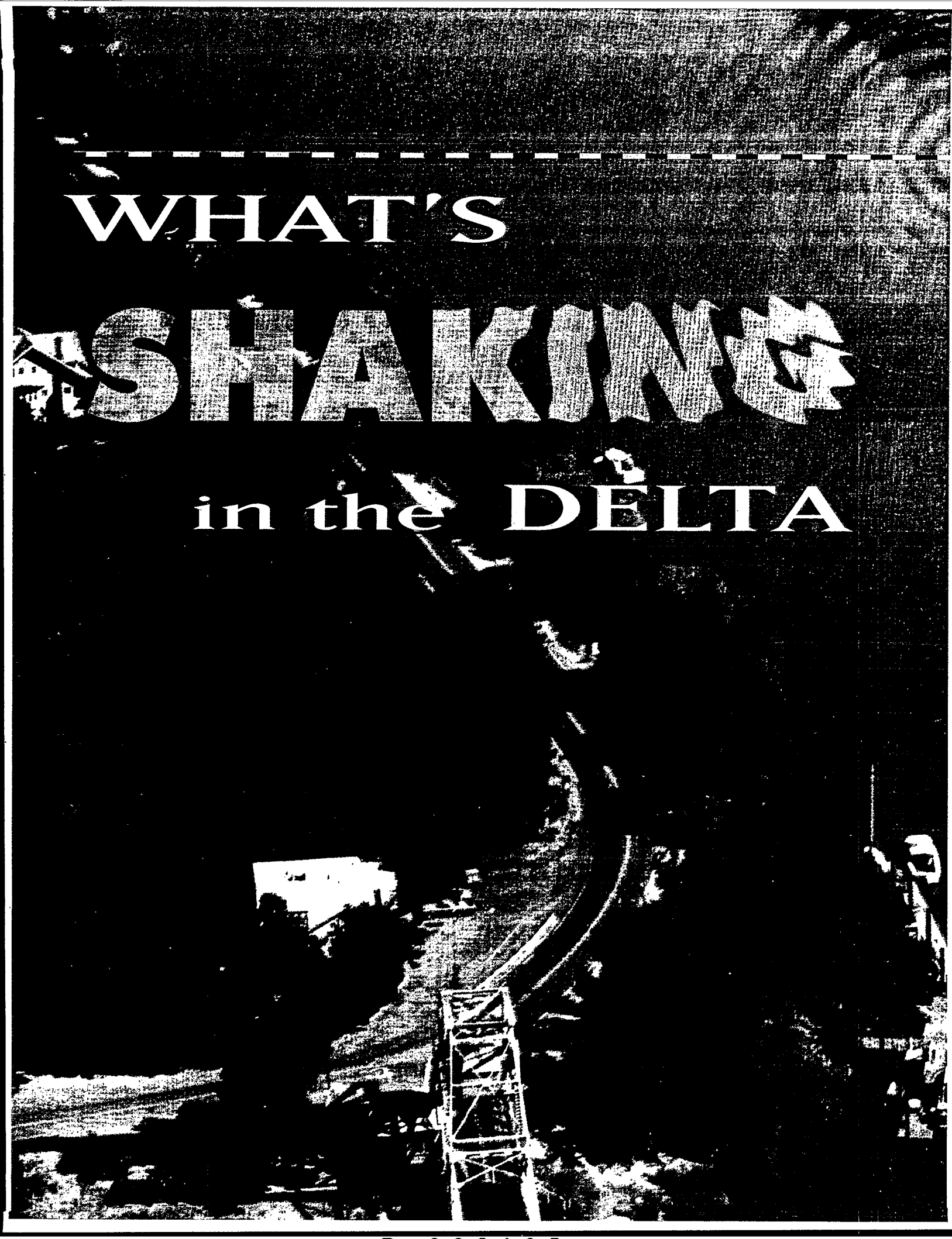

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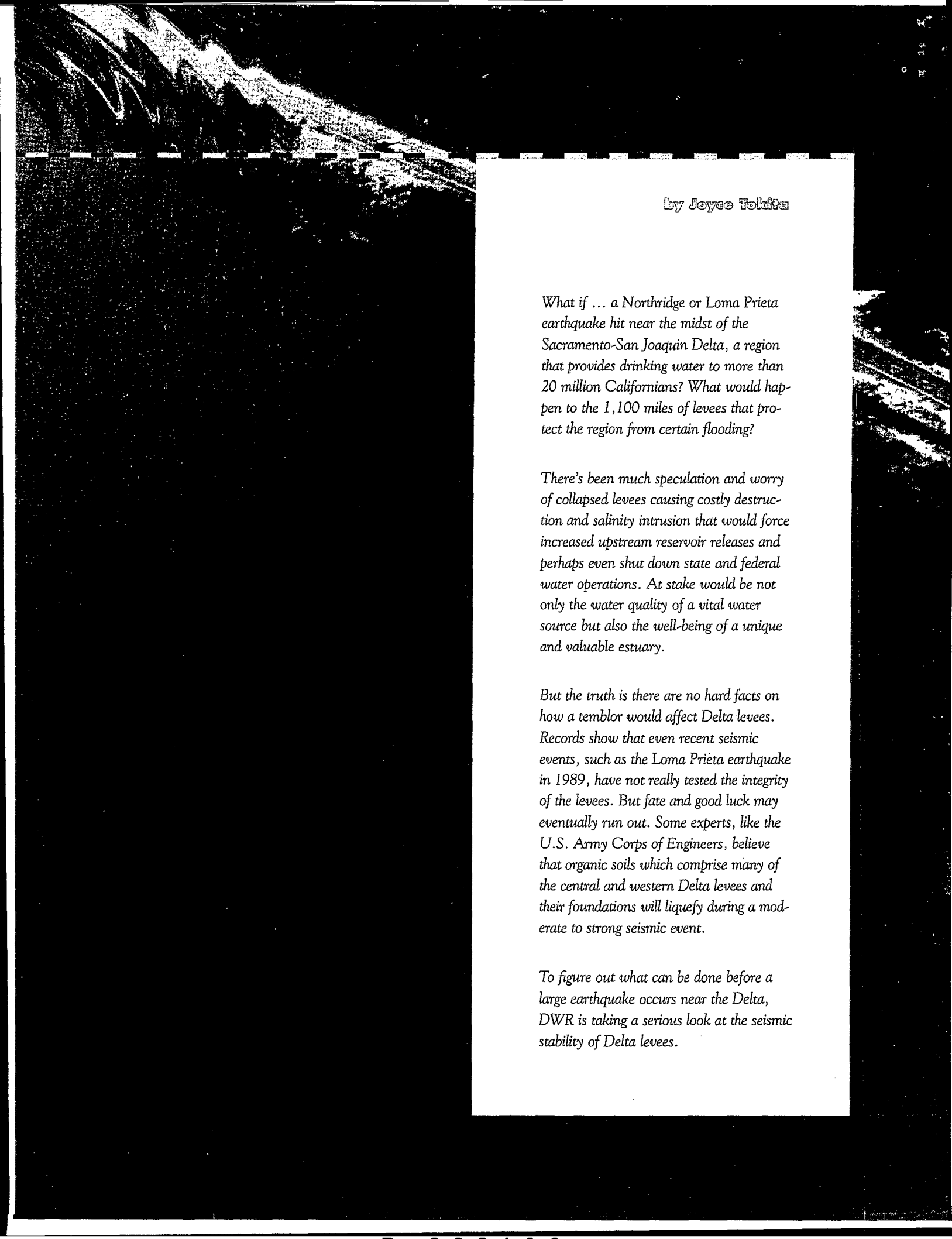

by Joyce Tokita

What if ... a Northridge or Loma Prieta earthquake hit near the midst of the Sacramento-San Joaquin Delta, a region that provides drinking water to more than 20 million Californians? What would happen to the 1,100 miles of levees that protect the region from certain flooding?

There's been much speculation and worry of collapsed levees causing costly destruction and salinity intrusion that would force increased upstream reservoir releases and perhaps even shut down state and federal water operations. At stake would be not only the water quality of a vital water source but also the well-being of a unique and valuable estuary.

But the truth is there are no hard facts on how a temblor would affect Delta levees. Records show that even recent seismic events, such as the Loma Prieta earthquake in 1989, have not really tested the integrity of the levees. But fate and good luck may eventually run out. Some experts, like the U.S. Army Corps of Engineers, believe that organic soils which comprise many of the central and western Delta levees and their foundations will liquefy during a moderate to strong seismic event.

To figure out what can be done before a large earthquake occurs near the Delta, DWR is taking a serious look at the seismic stability of Delta levees.

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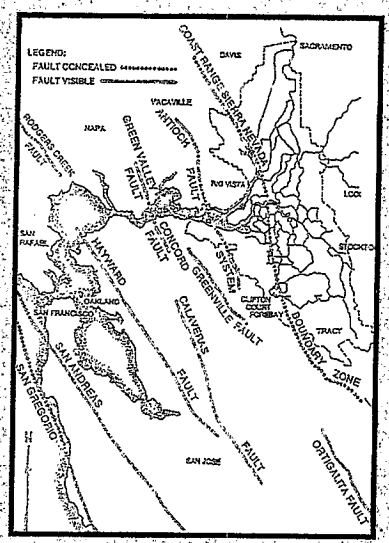
NEWS

DEPARTMENT OF WATER RESOURCES - SPRING 1997

D-028197

Regional Faults



Source:
Seismic Stability of Delta Levees
(DWR 1992)

New Study

"It's most critical that we determine the potential for Delta soils to either amplify or dampen out earthquake motions," says Les Harder, program manager of a new seismic study of the region.

"Delta levees are sitting on tens of feet of soft peaty soils. If these organic soils amplify ground motions, the behavior can have consequences much like what happened during the Loma Prieta earthquake."

During the 1989 temblor, much of the most serious damage occurred along the margin of the San Francisco Bay, an area composed of soft soils. "Though all of those sites, such as the Marina District, the Cypress Freeway, the Bay Bridge, and Oakland Harbor Airport, were 50 to 60 miles away from the epicenter, the soft soils beneath them amplified weak earthquake motions as much as five times greater than bedrock," Harder says. "This is potentially what can happen in the Delta."

Harder, however, is quick to point out that one 1967 recording of a magnitude 4.5 temblor in Union Bay near Seattle, Washington showed that the fibrous peaty soils there actually dampened motions.

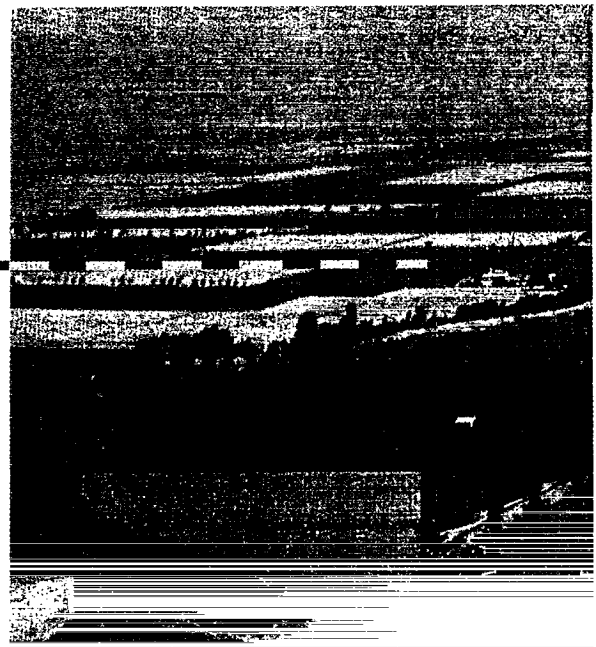
So the question remains: Will the Delta's peat soils hurt or help the levees? Data from the new study, coordinated by Harder and others in the Department, may begin to unravel the mystery.

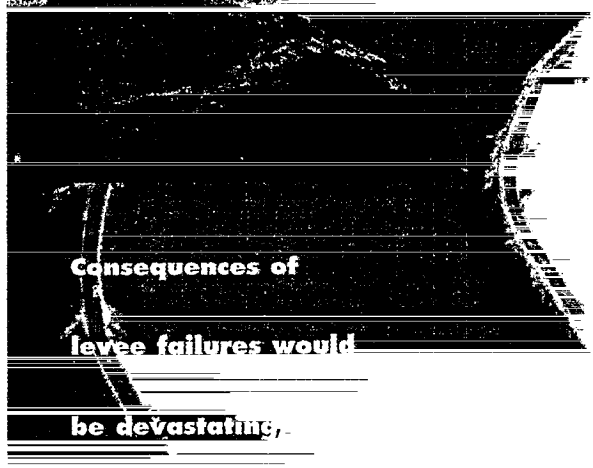
Though the Delta levees have yet to experience significant ground motion, the region lies in a seismically active area. U.S. Geologic Survey experts say the San Francisco Bay region was seismically very active during the 1800s and early 1900s but has been relatively quiet since 1911. However, that quiet period appeared to end in 1979 with four moderate to large earthquakes occurring in the region since then. These events suggest that the region is entering a cycle of increasing activity. In fact, one of their studies predicts that a magnitude 7.0 earthquake, similar to the Loma Prieta event, has a 67 percent chance of occurring within the next 30 years in the San Francisco-Oakland area on either the San Andreas or Hayward Faults.

"Concern for Delta levees is prompted by the fact that earthquake activity appears to have changed in the last 10-20 years. Magnitudes are larger and occurrences have been on unknown faults," confirms Dave Kessler, head of Earthquake Engineering. His section purchased and helped install surface and subsurface accelerometers at four sites in the Delta—Clifton Court, Montezuma Slough, Staten Island, and Sherman Island. Kessler and staff will also operate and maintain the equipment as well as retrieve (via computer modem) and process the data.

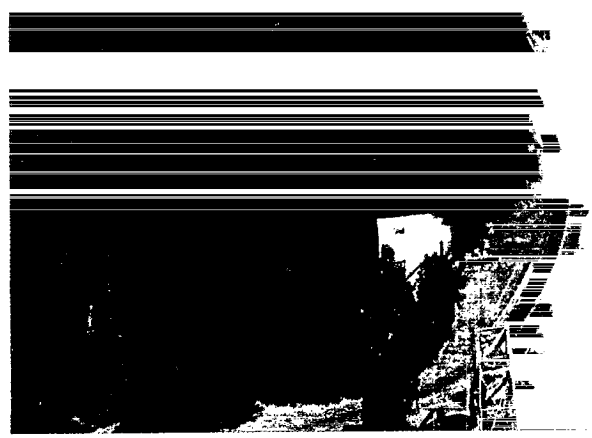
"The new equipment is much more sophisticated than what was previously at existing sites," Kessler says. Previously installed equipment at eight other Delta locations—one that dates back to 1969, when planning was underway for the Peripheral Canal—contain accelerometers that record surface motion only. At the new sites, in addition to sensors at the surface, three subsurface instruments to measure ground movement will be installed in boreholes in various depths down to 500 feet. The borehole drilling and casing installation for subsurface accelerometers were completed under the direction of the Project Geology Branch.

"Each instrument will contain three sensors that move in mutually perpendicular directions," explains Kessler. "That way, motion of a particle at depth can be reproduced and compared with one at the surface. Besides recording information at different geologic layers (peat, clay, sand, rock), the new equipment will provide digital data which can be manipulated and interpreted immediately."





Consequences of levee failures would be devastating, especially on the western Delta islands, which serve as barriers to help stem the tide of salt water intrusion into the interior Delta.



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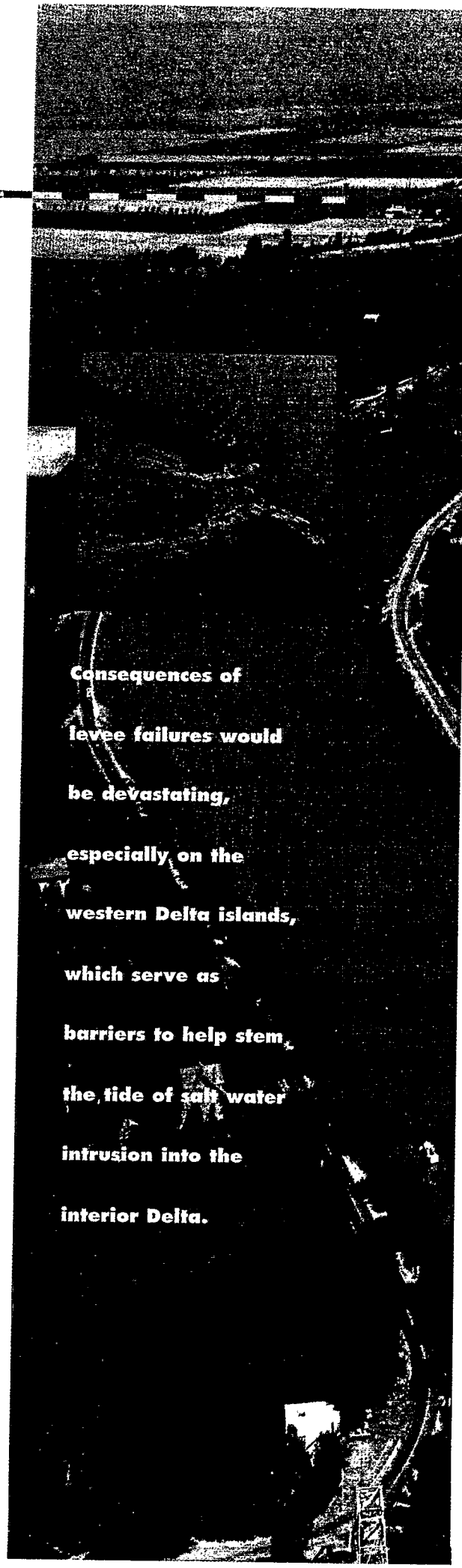

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New earthquake sensoring equipment will be located on levees composed of soft soils. Four sites with different foundations were selected - including Sherman Island (above) where the levee is very large, with the peat soil beneath around 35 feet thick.

All four sites are located on levees composed of soft soils. "We picked areas with different foundations," adds Harder. "For example, at Sherman Island, the levee is very large, with the peat soil beneath around 35 feet thick; while at Clifton Court, the levee is smaller with smaller amounts of organics. Ideally, we'd like to see what happens when an earthquake or series of earthquakes trigger motions that would impact each site. That way we can learn how different organic soils behave under similar conditions."

The data obtained from the new equipment will document the kinds of ground motions created by earthquakes, assess whether the Delta's soft, organic soils will amplify or dampen earthquake movements, and estimate how well levees and other structures will fare under different levels of earthquake motion. Recordings will also be compared to computer models that can simulate different levee profiles (based on soil densities, foundation conditions and other characteristics), then simulate different intensities of earthquake motion to project the effects. In this way, information from more commonly occurring smaller or distant earthquakes can be used to predict behavior for a future large earthquake.

"One earthquake won't settle all the questions," says Kessler. "In fact, it may raise other questions."

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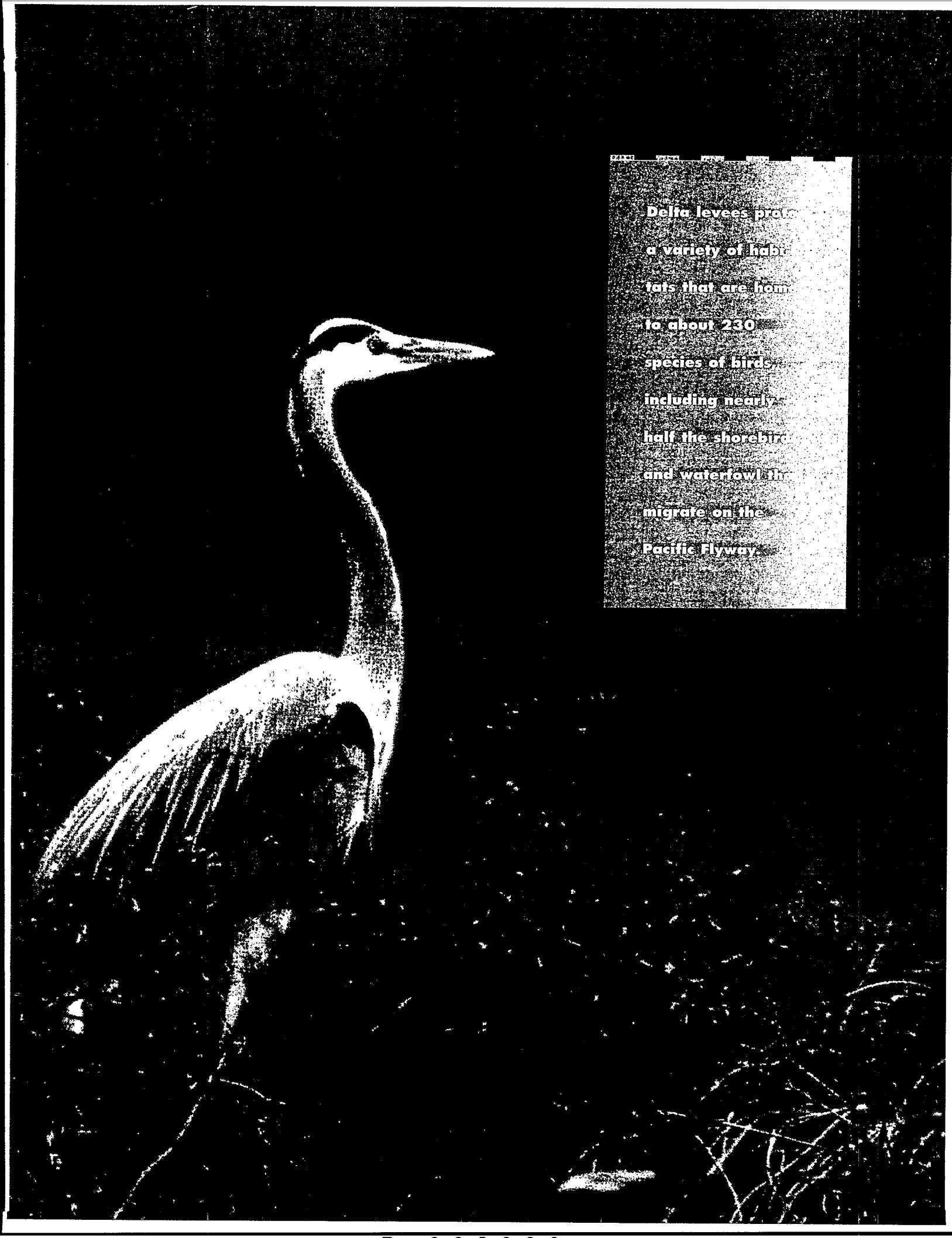
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including nearly
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Past Results, Future Outlook

No detailed evidence exists of how Delta levees have fared in past earthquakes. Reviews of past newspaper stories, engineering journals, and eyewitness accounts reveal no levee failure or even serious damage resulting from temblors. The most serious damage reported was during the 1906 San Francisco earthquake during which a Santa Fe railroad bridge at the Middle River crossing was displaced by about three feet.

"Historically, since reclamation began in the area, the Delta has experienced only low levels of shaking," says Les Harder, "so the levees have never really been tested."

There is a growing belief among geologists that the Delta area may include blind thrust faults. These are hidden faults that, when they rupture, don't show on the surface. The Northridge Earthquake occurred along one. "Because there is no surface expression such as large cracks or offsets in the ground, you can't map the faults or see them in aerial photos," explains Harder. "But as demonstrated by the Northridge event, these types of earthquakes still produce a lot of shaking and damage."

Even fairly recent studies conducted over the past 12 years fail to fully reveal the region's seismic hazards. The results, however, are considered preliminary because of the long lengths of levees involved, the lack of information on the levees themselves and their foundations, and the question of whether organic soils would amplify or attenuate (dampen) ground motions.

"Historically, we haven't recorded much in the Delta because there is little instrumentation in the region, and the large earthquakes have occurred in other regions," says Dave Kessler.

Though limited, previous findings do point to certain vulnerable spots. A 1987 Corps of Engineers study shows that the central Delta is considered to have a moderate to high potential for liquefaction, and a 1992 Earth Sciences Associates evaluation predicts about a 90 percent probability that levees along the Delta's western edge will liquefy during an earthquake within the next 30 years. The Department's preliminary studies, documented in a 1992 Design and Construction report, also show the levees on the western edge of the Delta to be at risk within the next 30 years. This risk potential generally decreases towards the east side of the region.

Information from the new study will build on the database. "The more we know about the relative vulnerability of Delta levees, the better we can plan and be prepared," Harder says. "While it may not be economically feasible to upgrade most reaches to meet earthquake safety standards, we can pursue a rational approach of managing existing and future Delta facilities and resources."

What that means is too early to say. New study results will still be limited in scope. However, the Department is looking into conducting more extensive joint investigations with other agencies and universities.

"We do know that the potential for trouble in the Delta is great," adds Harder. "And we need to know the magnitude of those risks and raise the accuracy of our predictions."

"The more we know about the relative vulnerability of Delta levees, the better we can plan and be prepared."

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